研究報告

PSYCHOLOGICAL DIMENSIONS OF RISK PERCEPTION AND INFORMATION[1]

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1. INTRODUCTION

Scientific measurement of risk, such as probabilistic risk assessment (PRA), is often found to contradict public reactions to risk. Scientific risk assessment and risk perception by humans thus may be considered as being dictated by different kinds of rules and subject to different systems of measurement. A recent UNSCEAR report (1993) on perception of risks from radiation and other sources lists 19 "dimensions of perceived risk" which include "familiarity," "uncertainty," "voluntary nature," "personal involvement," "controllability," "moral value," "catastrophic potential," "dread," "benefit" and "media attention." A question might arise at this point as to whether all these differentiated "dimensions" may equally contribute to risk perception, and whether they may correspond to perceptual organization of humans.

To answer part of the question, the present paper attempts to investigate perceptual organization regarding risk by way of semantic differential, drawing attention to the result of recent risk perception studies conducted in Japan by the present author. This paper will first illustrate psychological measurement of perceived risk; second, psychological trade-off between perceived risk and benefit; and, finally, a generalized model of psychological dimensionality in risk perception.

2. PSYCHOLOGICAL MEASUREMENT OF RISK PERCEPTION

C. E. Osgood *et al.* (1957, 1975) have offered an reliable psychological measuring instrument they termed "semantic differential" in order to measure "feeling tone" of various cognitive events. This method can be used to measure both the intensity and directions of feeling (or affective responses) which might be aroused toward various cognitive events. The following tables and figures will summarize major findings of our studies where semantic differential was used throughout as the measuring tool.

Figures 1 and 2 (Tanaka, 1982) display the average affective meaning of various objects, which was first measured by the semantic differential method, and subsequently allocated in a two-dimensional space defined by the risky-safe and the beneficial-non-beneficial semantic

differential scales. To summarize the measuring procedure, an N of subjects rate the objects of judgment against a set of five-point scales. In the present case, only two scales were used – risky-safe and beneficial-non-beneficial. For each object, the scale value is averaged over an N of subjects. In theory, the scale averages range from the minimum of 1 to the maximum of 5. To make the interpretation of data easier, these scale averages are transformed into what is called "the polarity scores," ranging from – 2 through 0 to +2. By using the two polarity scores, one for the risky-safe scale and another for the beneficial-non-beneficial, each object can be plotted in a two-dimensional space like Figures 1 and 2, which is in turn dissolved into four quadrants.

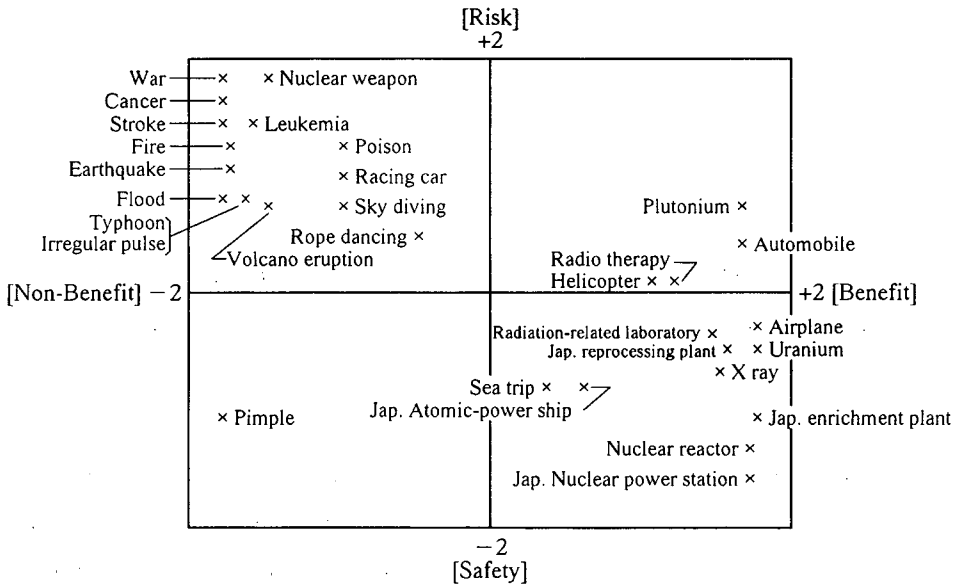

Fig. 1. Risk/Benefit Perception in Nuclear Experts (N = 545, 1981)

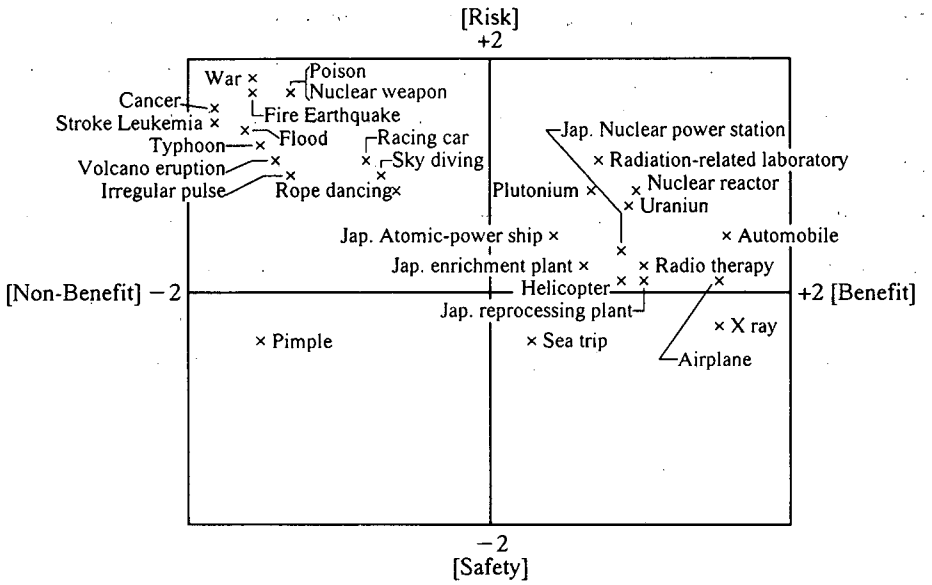

Fig. 2. Risk/Benefit Perception in Lay Public (N = 474, 1983)

Let us next look into how each quadrant reads. The first quadrant on upper-left reads "risky and non-beneficial"; the second quadrant on upper right, "risky and beneficial"; the third quadrant on lower right, "safe and beneficial"; and the fourth quadrant on lower left, "safe and non-beneficial." It will be noted in Table 1 for the nuclear experts and in Table 2 for the lay public that physically and socially objectionable events like WAR, NUCLEAR WEAPON, LEUKEMIA, or EARTHQUAKE are all allocated in the first quadrant defined as risky and non-beneficial, similarly in the two subject groups. It is interesting to find that PIMPLE is assigned to the fourth quadrant defined as safe but non-beneficial, again similarly in both groups, although it would have been rated somewhat differently by younger subjects. Sharp differences are observed, however, in the second and the third quadrants where the nuclear experts and the lay public tend to perceive the same objects very differently. While the experts assign most of radiation- or radioactivity-related events in the third quadrant meaning both safe and beneficial, the lay public mostly assign them to the second quadrant meaning risky and beneficial. Here, it is clearly seen that major perceptual differences between the nuclear experts and the lay public tend to occur in a vertical direction, that is, along the risky-safe axis. Thus, what are viewed by the experts as being safe are felt by the lay public as being risky. The meaning of the objects like NUCLEAR REACTOR, JAPANESE NUCLEAR POWER

STATION, and RADIATION-RELATED LABORATORY shift from being safe in the experts to being risky in the lay public. In this respect, it is also interesting to note that even the experts regard PLUTONIUM and RADIO THERAPY as being risky. It can be assumed that, if the intensity of feeling risky is greater than that of feeling beneficial, people would tend to avoid such objects.

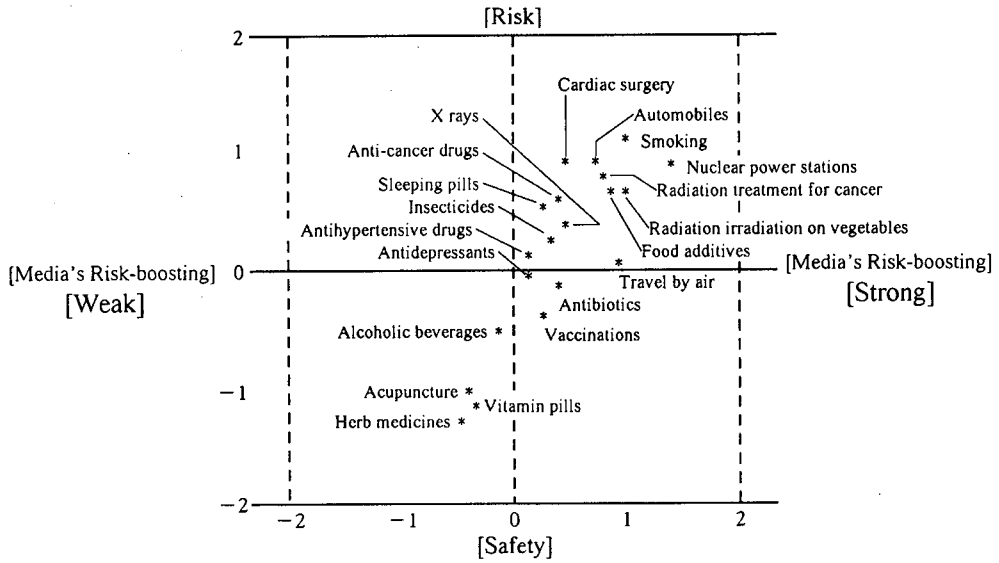

Fig. 3. Risk Perception and Media Effects in Lay Public (N = 630, 1988)

In a separate analysis (Tanaka, 1991), correspondence between media attention and the degree of concerns among people was also examined. Twenty objects of judgment were rated by a sample lay public against two scales: one for the rating of perceived risk and another for the perceived degree of mass media's attention if an accident should happen. Then they were plotted in a two dimensional space defined by both scales, as displayed in Figure 3. It appears clear that the more risky the objects, the more the media's attention, or vice versa, although from such correspondence anything about causality between the two cannot be concluded. It may well be assumed, however, that there might be some intense interaction between the two, the mass media sensitizing the perceptiveness of the public toward the events which might endanger their life, health or property, and the public in return responding to the mass media by drawing more attention to such events. Such interactions would grow in spiral, as might be the case with SMOKING or NUCLEAR POWER STATION.

3. PSYCHOLOGICAL DIMENSIONS OF RISK PERCEPTION

When submitted to a statistical operation called factor analysis, different scales may be grouped into orthogonal factors or psychological dimensions, based upon their correlational characteristics. Tables 1, 2 and 3 (Tanaka, 1993) display the results of factor analysis of somewhat different sets of scales, against which advanced-technology-related objects were rated in two separate studies conducted in 1992; one for Japanese national opinion leaders and another for the lay public. The purpose of these studies were to examine psychological dimensions of perceived risk associated with advanced-technology-related objects. In the opinion leaders study, a total of 15 objects were rated against a set of 8 scales (① safe/risky, ② useful/useless for mankind, ③ useful/useless for myself, ④ not concerned/concerned, ⑤ easy/hard to self-determine, ⑥ low/high probability of accident, ⑦ small/large damage should an accident occur, and ⑧ con/pro for abandoning), whereas in the lay public study, 14 objects were rated against a set of only 4 scales (① feeling necessary, ② feeling useful, ③ feeling safe and ④ feeling at ease).

Table 1. Factor Analytic Results for 15 Events in the Opinion Leaders (N = 1722; 1992)

〔1. SOLAR POWER GENERATION〕

	I	II	III	IV
① SAFE/RISKY	.86			
② USEFUL/USELESS FOR MANKIND		.86		
③ USEFUL/USELESS FOR MYSELF				.83
④ NOT CONCERNED/CONCERNED	.87			
⑤ EASY/HARD TO SELF-DETERMINE			.83	
⑥ LOW/HIGH PROBABILITY OF ACCIDENT	.76			
⑦ SMALL/LARGE DAMAGE	.57			
⑧ CON/PRO FOR ABANDONING		.74		

〔2. GEO-THERMAL POWER GENERATION〕

	I	II	III	IV
① SAFE/RISKY	.77			
② USEFUL/USELESS FOR MANKIND		.69		
③ USEFUL/USELESS FOR MYSELF			.90	
④ NOT CONCERNED/CONCERNED	.78			
⑤ EASY/HARD TO SELF-DETERMINE				.90
⑥ LOW/HIGH PROBABILITY OF ACCIDENT	.86			
⑦ SMALL/LARGE DAMAGE	.80			
⑧ CON/PRO FOR ABANDONING		.83		

〔3. NUCLEAR POWER GENERATION〕

	I	II	III	IV
① SAFE/RISKY		.85		
② USEFUL/USELESS FOR MANKIND	.87			
③ USEFUL/USELESS FOR MYSELF	.87			
④ NOT CONCERNED/CONCERNED		.81		
⑤ EASY/HARD TO SELF-DETERMINE				.96
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.72		
⑦ SMALL/LARGE DAMAGE			.94	
⑧ CON/PRO FOR ABANDONING	.74	.50		

〔4. NUCLEAR FUSION〕

	I	II	III	IV
① SAFE/RISKY		.83		
② USEFUL/USELESS FOR MANKIND	.87			
③ USEFUL/USELESS FOR MYSELF	.83			
④ NOT CONCERNED/CONCERNED		.71		
⑤ EASY/HARD TO SELF-DETERMINE				.96
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.75		
⑦ SMALL/LARGE DAMAGE			.91	
⑧ CON/PRO FOR ABANDONING	.80			

〔5. RADIOTHERAPY FOR CANCER〕

	I	II	III	IV
① SAFE/RISKY		.86		
② USEFUL/USELESS FOR MANKIND	.86			
③ USEFUL/USELESS FOR MYSELF	.82			
④ NOT CONCERNED/CONCERNED		.78		
⑤ EASY/HARD TO SELF-DETERMINE				.95
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.69		
⑦ SMALL/LARGE DAMAGE			.92	
⑧ CON/PRO FOR ABANDONING	.77			

〔6. RADIATION STERILIZATION FOR VEGETABLES〕

	I	II	III	IV
① SAFE/RISKY		.71		
② USEFUL/USELESS FOR MANKIND	.81			
③ USEFUL/USELESS FOR MYSELF	.85			
④ NOT CONCERNED/CONCERNED		.64		
⑤ EASY/HARD TO SELF-DETERMINE				.98
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.57	.57	
⑦ SMALL/LARGE DAMAGE			.90	
⑧ CON/PRO FOR ABANDONING	.86			

〔7. GENE RECOMBINATION〕

	I	II	III	IV
① SAFE/RISKY		.84		
② USEFUL/USELESS FOR MANKIND	.86			
③ USEFUL/USELESS FOR MYSELF	.80			
④ NOT CONCERNED/CONCERNED		.76		
⑤ EASY/HARD TO SELF-DETERMINE				.99
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.61		
⑦ SMALL/LARGE DAMAGE			.90	
⑧ CON/PRO FOR ABANDONING	.86			

〔8. GEO-THERMAL POWER GENERATION〕

	I	II	III	IV
① SAFE/RISKY		.88		
② USEFUL/USELESS FOR MANKIND	.88			
③ USEFUL/USELESS FOR MYSELF	.77			
④ NOT CONCERNED/CONCERNED		.72		
⑤ EASY/HARD TO SELF-DETERMINE				.99
⑥ LOW/HIGH PROBABILITY OF ACCIDENT			.67	
⑦ SMALL/LARGE DAMAGE			.90	
⑧ CON/PRO FOR ABANDONING	.85			

〔9. SUPER-CONDUCTIVITY〕

	I	II	III	IV
① SAFE/RISKY		.77		
② USEFUL/USELESS FOR MANKIND			.66	
③ USEFUL/USELESS FOR MYSELF		.65		
④ NOT CONCERNED/CONCERNED		.63		
⑤ EASY/HARD TO SELF-DETERMINE				.90
⑥ LOW/HIGH PROBABILITY OF ACCIDENT	.79			
⑦ SMALL/LARGE DAMAGE	.88			
⑧ CON/PRO FOR ABANDONING		.89		

〔10. SUPER HIGH-RISE BUILDINGS〕

	I	II	III	IV
① SAFE/RISKY	.68			
② USEFUL/USELESS FOR MANKIND		.81		
③ USEFUL/USELESS FOR MYSELF		.89		
④ NOT CONCERNED/CONCERNED	.73			
⑤ EASY/HARD TO SELF-DETERMINE				.98
⑥ LOW/HIGH PROBABILITY OF ACCIDENT	.84			
⑦ SMALL/LARGE DAMAGE			.94	
⑧ CON/PRO FOR ABANDONING	.60	.60		

〔11. OCEAN-BED EXPLORATION〕

	I	II	III	IV
① SAFE/RISKY		.89		
② USEFUL/USELESS FOR MANKIND	.88			
③ USEFUL/USELESS FOR MYSELF	.70			
④ NOT CONCERNED/CONCERNED		.70		
⑤ EASY/HARD TO SELF-DETERMINE				.96
⑥ LOW/HIGH PROBABILITY OF ACCIDENT			.71	
⑦ SMALL/LARGE DAMAGE			.90	
⑧ CON/PRO FOR ABANDONING	.85			

〔12. UNDERGROUND-SPACE EXPLORATION〕

	I	II	III	IV
① SAFE/RISKY		.78		
② USEFUL/USELESS FOR MANKIND	.84			
③ USEFUL/USELESS FOR MYSELF	.81			
④ NOT CONCERNED/CONCERNED		.76		
⑤ EASY/HARD TO SELF-DETERMINE				.97
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.76		
⑦ SMALL/LARGE DAMAGE			.89	
⑧ CON/PRO FOR ABANDONING	.78			

〔13. ANTI-CANCER DRUGS〕

	I	II	III	IV
① SAFE/RISKY		.86		
② USEFUL/USELESS FOR MANKIND	.86			
③ USEFUL/USELESS FOR MYSELF	.72			
④ NOT CONCERNED/CONCERNED		.75		
⑤ EASY/HARD TO SELF-DETERMINE				.96
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.60	.56	
⑦ SMALL/LARGE DAMAGE			.88	
⑧ CON/PRO FOR ABANDONING	.83			

〔14. HERB MEDICINE〕

	I	II	III	IV
① SAFE/RISKY	.57	.51		
② USEFUL/USELESS FOR MANKIND	.78			
③ USEFUL/USELESS FOR MYSELF	.87			
④ NOT CONCERNED/CONCERNED	.48		.48	
⑤ EASY/HARD TO SELF-DETERMINE			.87	
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.73		
⑦ SMALL/LARGE DAMAGE		.90		
⑧ CON/PRO FOR ABANDONING			.83	

〔15. VITAMINS〕

	I	II	III	IV
① SAFE/RISKY	.73			
② USEFUL/USELESS FOR MANKIND	.52		.68	
③ USEFUL/USELESS FOR MYSELF	.83			
④ NOT CONCERNED/CONCERNED	.73			
⑤ EASY/HARD TO SELF-DETERMINE				.95
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.72		
⑦ SMALL/LARGE DAMAGE		.89		
⑧ CON/PRO FOR ABANDONING			.85	

For the opinion leaders, separate scale factorization was attempted for each object to examine how factor structure may vary from one object to another. The results of these factor analyses in the Opinion Leaders Study are displayed in Table 1 by object, where only high (both primary and secondary) factor loadings are shown. It is clearly noted that two factors are the most salient – SAFETY with the safe/risky scale loading high on this factor, and USEFULNESS with the useful/useless for mankind and the useful/useless for myself scales loading high on this factor. It is also noted that the con/pro for abandoning appears to shift its "associative meaning" from one case to another; sometimes it is associated with safe/risky, and sometimes, with useful/useless for mankind as well as useful/useless for myself. Note, for example, the opinion leaders are NOT IN FAVOR OF ABANDONING both "SOLAR POWER GENERATION" and "GEO-THERMAL POWER GENERATION" because these are

USEFUL FOR MANKIND. On the other hand, they seem to be NOT IN FAVOR OF ABANDONING "NUCLEAR POWER GENERATION" for two independent reasons (note the high loadings on both the first and the second factors) − not only because it is USEFUL FOR MANKIND and USEFUL FOR MYSELF, but also only if it is SAFE, has LOW PROBABILITY OF ACCIDENT, and makes them NOT CONCERNED. It is also interesting to find that opinion leaders are NOT IN FAVOR OF ABANDONING "HERB MEDICINE," with a very high loading on Factor V, and on this factor alone, independent from any other factors, whereas they are NOT IN FAVOR OF ABANDONING "VITAMINS" because they feel it USEFUL FOR MANKIND.

Table 2. Factor Analysis and Multiple Regression Analysis in the Opinion Leaders (N = 1722; 1992)

〔1. SOLAR POWER GENERATION〕

	FI	FII	FIII	FIV	R^2= .41**	β
① SAFE/RISKY	.86					.29
② USEFUL/USELESS FOR MANKIND		.86				.51
③ USEFUL/USELESS FOR MYSELF				.83		
④ NOT CONCERNED/CONCERNED	.87					
⑤ EASY/HARD TO SELF-DETERMINE			.83			
⑥ LOW/HIGH PROBABILITY OF ACCIDENT	.76					
⑦ SMALL/LARGE DAMAGE	.57		.58			
⑧ CON/PRO FOR ABANDONING		.74				

〔2. NUCLEAR POWER GENERATION〕

	FI	FII	FIII	FIV	R^2= .72**	β
① SAFE/RISKY		.85				.38
② USEFUL/USELESS FOR MANKIND	.87					.67
③ USEFUL/USELESS FOR MYSELF	.87					
④ NOT CONCERNED/CONCERNED		.81				
⑤ EASY/HARD TO SELF-DETERMINE				.96		
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		72				
⑦ SMALL/LARGE DAMAGE			.94			
⑧ CON/PRO FOR ABANDONING	.74	.50				

〔3. NUCLEAR FUSION〕

	FI	FII	FIII	FIV	R^2= .69**	β
① SAFE/RISKY		.83				.37
② USEFUL/USELESS FOR MANKIND	.87					.65
③ USEFUL/USELESS FOR MYSELF	.83					
④ NOT CONCERNED/CONCERNED		.71				
⑤ EASY/HARD TO SELF-DETERMINE				.96		
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.75				
⑦ SMALL/LARGE DAMAGE			.91			
⑧ CON/PRO FOR ABANDONING	.80					

〔4. RADIO-THERAPY FOR CANCER〕

	FI	FII	FIII	FIV	R^2= .55**	β
① SAFE/RISKY		.86				.24
② USEFUL/USELESS FOR MANKIND	.86					.67
③ USEFUL/USELESS FOR MYSELF	.82					
④ NOT CONCERNED/CONCERNED		.78				
⑤ EASY/HARD TO SELF-DETERMINE				.95		
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.69				
⑦ SMALL/LARGE DAMAGE			.92			
⑧ CON/PRO FOR ABANDONING	.77					

〔5. RADIATION STERILIZATION FOR VEGETABLES〕

	FI	FII	FIII	FIV	R^2= .72**	β
① SAFE/RISKY		.71				.26
② USEFUL/USELESS FOR MANKIND	.81					
③ USEFUL/USELESS FOR MYSELF	.85					
④ NOT CONCERNED/CONCERNED		.64				
⑤ EASY/HARD TO SELF-DETERMINE				.98		
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.57	.57			
⑦ SMALL/LARGE DAMAGE			.90			
⑧ CON/PRO FOR ABANDONING	.86					

〔6. ANTI-CANCER DRUGS〕

	FI	FII	FIII	FIV	R^2= .45**	β
① SAFE/RISKY		.86				.16
② USEFUL/USELESS FOR MANKIND	.86					.66
③ USEFUL/USELESS FOR MYSELF	.72					
④ NOT CONCERNED/CONCERNED		.75				
⑤ EASY/HARD TO SELF-DETERMINE				.96		
⑥ LOW/HIGH PROBABILITY OF ACCIDENT		.60	.56			
⑦ SMALL/LARGE DAMAGE			.88			
⑧ CON/PRO FOR ABANDONING	.83					

[Note] (**) indicates $p < .01$.

Next, by using a statistical test called multiple regression analysis, it is possible to examine whether the acceptance (in the present case, NOT IN FAVOR OF ABANDONING) of an object as the dependent variable can be meaningfully predicted by a number of independent variables. Table 2 shows how the acceptance can be predicted from the perceived safety and the perceived usefulness in their judging of six objects. Six events were chosen because five out of the six are all related to radiation or radioactivity and the remaining one, ANTI-CANCER DRUGS, is used for comparison with RADIO-THERAPY FOR CANCER. In addition, in Table 2, R^2 stands for the amount of variance accounted for by the multiple correlation, R, while β indicates the relative importance of the two independent variables. In the same table, the factor analytic result is also shown in order to confirm that the two independent variables are indeed independent.

Having said this, let us next look at the results of these multiple regression analyses. Every multiple correlation proves significant beyond the .01 level and the β weight for USEFULNESS (FOR MANKIND) is always greater than that of SAFETY in every case examined. It may well be remembered that all the events examined are related to radiation or radioactivity or cancer, all of which can be fatal. The only reason for accepting these potentially fatal events or objects may be that the subjects tend to feel them useful, probably more than they feel them risky.

Table 3. Factor Analysis and Multiple Regression Analysis in the Lay Public (N = 1511; 1992)

(1) FACTOR ANALYSIS (TECHNOLOGY IN GENERAL)

	Factor I	Factor II
feeling necessary	.22	.70
feeling useful	.23	.74
feeling safe	.75	.18
feeling at ease	.76	.25

(2) MULTIPLE REGRESSION ANALYSIS

	R^2	β (feeling necessary)	β (feeling at ease)
(1) SOLAR POWER PLANT	.55**	.33	.54
(2) NUCLEAR POWER PLANT	.64**	.56	.36
(3) NUCLEAR FUSION POWER PLANT	.53**	.46	.39
(4) RADIO-THERAPY FOR CANCER	.38**	.44	.32
(5) RADIATION STERILIZATION FOR VEGETABLES	.57**	.46	.42
(6) ANTI-CANCER DRUGS	.44**	.51	.30

[Note] (**) indicates $p < .01$.

Similar results were obtained in the lay public as well, as displayed in Table 3. The factor analytic result indicates that the four scales are grouped into two factors, SAFETY and NECESSITY. The results of the multiple regression analysis of six objects clearly show again that, except for "SOLAR POWER PLANT," more importance is assigned to USEFULNESS than to SAFETY similarly across the five objects. "SOLAR POWER PLANT" is still at an experimental stage and there may be some wishful thinking about it in the lay public. Because it is neither in full use nor in fact useful at the present, only its safety is strongly perceived, so that the acceptance of it can be predicted more from its perceived safety than from its perceived usefulness.

4. CONCLUSIONS

The results of four separate studies on the perception of technology-related events are reported in the present paper. First, various events were rated against safe/risky and

beneficial/not beneficial scales and allocated in a two-dimensional space with a sample of nuclear experts and a sampled of the lay public serving as subjects. The result indicated that the major differences between the experts and the lay public judging nuclear-related events tend to occur along the safe/risky axis, so that what is perceived as safe by the nuclear experts tend to be perceived as risky by the lay public. Almost all the radiation-related events were perceived as risky by the lay public.

Second, correspondence between media's attention and perceived risk are examined by plotting various events in a two dimensional space defined by the two independent conditions. It was discovered that the media's attention tends to correspond with the perceived risk, or vice versa, although causality between the two cannot be determined in this study.

Third, technology-related events were rated against a set of judgmental scales and these scales factor-analyzed in both opinion leaders and the lay public. The factor analytic results clearly showed that two factors, SAFETY and USEFULNESS, are the two most salient factors in the judging of these events in both groups. In the opinion leaders where 8 scales were used, the factor structure appears to vary from one event to another, probably reflecting the physical and social characteristics of each event. By using the varimax factor rotation scheme which aims at the mathematical solution for simple structure, the 19 dimensions listed in the UNSCEAR report (1993) could be reduced in numbers − down to the two most salient factors, SAFETY and USEFULNESS.

Fourth, by using multiple regression solution, it was possible to predict the acceptance of an event from two independent variables − SAFETY and USEFULNESS. The statistical tests prove that all the predictions are significant beyond the .01 level and, in the most cases examined, USEFULNESS tends to be more important than SAFETY in predicting the acceptance.

The foregoing results seem to suggest that psychological dimensions of risk and benefit (usefulness) perception may well be imbedded in the innate psychological process (in the sense that humans try to avoid something dangerous and adopt something useful for physical survival and cultural development − Tanaka, 1989) while the perception of what is dangerous and what is useful may vary among individuals, depending upon the input information one might obtain directly from the environment or indirectly via mass media, or, in a more generic term, through the cultural learning.

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Footnote

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